Space Weather Technical Forecast

Issued on Saturday, 14 September 2024 at 00:21 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: G1-G2 Minor to Moderate storms with CME arrival expected on Day 1 (14 Sep) and perhaps Day 3 (16 Sep). Further M-class flares expected, with a chance X-class flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High activity with a peak flare M5.4 at 13/0656 UTC, likely from AR3811 from over the southwest limb. Frequent M-flares where observed, with an extended period from 12/2140-013/0936 UTC where the background X-ray irradiance persisted above the M-class level due to the flaring on the southwest limb. Further M-flaring is likely from this region, with a slight chance of X-flares, however this risk is reducing as this recedes around the limb. Significant flaring is also possible from AR3825 in the southeast, as this was the source of the X1.3 flare on 12 Sep. Given the notable magnetic looping on the southeast limb, there remains a chance of proton events, although recent flaring from this area currently appears to have not ejected protons observable at GOES.

A filament eruption, most likely associated with the M2.9 flare observed at 13/0835 UTC from AR3814, was observed on SDO imagery at around 13/0930 UTC. While the bulk of the ejecta is expected to pass ahead of Earth's orbit towards Stereo-A, it may still be able to give a glancing blow on the 16th (Day 3). Other and often large CMEs were observed but these are not deemed to be Earth-directed.

Solar Wind / Geomagnetic Activity: Solar wind parameters, as observed by ACE at L1, are indicative of the waning influence of the CME that arrived at Earth on 12 Sep. Solar wind speeds were quite erratic but reduced from 500 to 450 km/s, along with below average density. The Interplanetary Magnetic Field (IMF) Bt, was Weak to Moderate, between 06-10nT, while the north-south component, Bz, remained largely negative, reaching -9nT between 13/1930-2130 UTC. Phi angle was largely positive (away from the Sun). The net result of these parameters was for Unsettled to Active geomagnetic activity, with two G2 Moderate storm intervals between 13/0000-0300 UTC and 13/2100-2400 UTC.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 remained at background. High energy electron flux (greater than 2MeV) observed by GOES16 briefly rose to elevated levels, peaking at 1140pfu at 13/1645 UTC before returning to background levels. The associated 24-hour fluence showed a sharp rising trend but remained below the Active threshold, with 1.77e7 integrated pfu observed at 14/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: High to Moderate activity expected with M-class flares expected and a chance of further X-class flares, albeit decreasing as the southwest activity rotates further onto the far-side.

Solar Wind / Geomagnetic Activity: Solar winds are still slightly elevated after the recent CME arrival on 12 Sep. There are two further CME arrivals in the forecast - first one on Day 1 (14

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Sep) and the second one on Day 3 (16 Sep) - plus the potential onset of the high speed stream of CH68 and CH69 on Days 2 & 3 (15 & 16 Sep). Geomagnetic activity is expected to be Active to G1/G2 Minor/Moderate Storms on Day 1 (14 Sep) with a slight chance of isolated G3 Strong storms possible. Mostly Quiet to Unsettled by Day 2 (15 Sep) but Unsettled to Active on Day 3 (16 Sep) with isolated G1 Minor Storm possible. Down to Quiet and Unsettled by Day 4 (17 Sep).

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain near background. However current activity on the southeast limb gives a chance of proton flux rising, most likely on day 1-2 (14-15 Sep), with a chance of exceeding the S1 Minor Radiation storm level. This risk receding later in the period. High energy electron flux is expected to remain mainly at Background with the associated 24 hour fluence remaining below Active.

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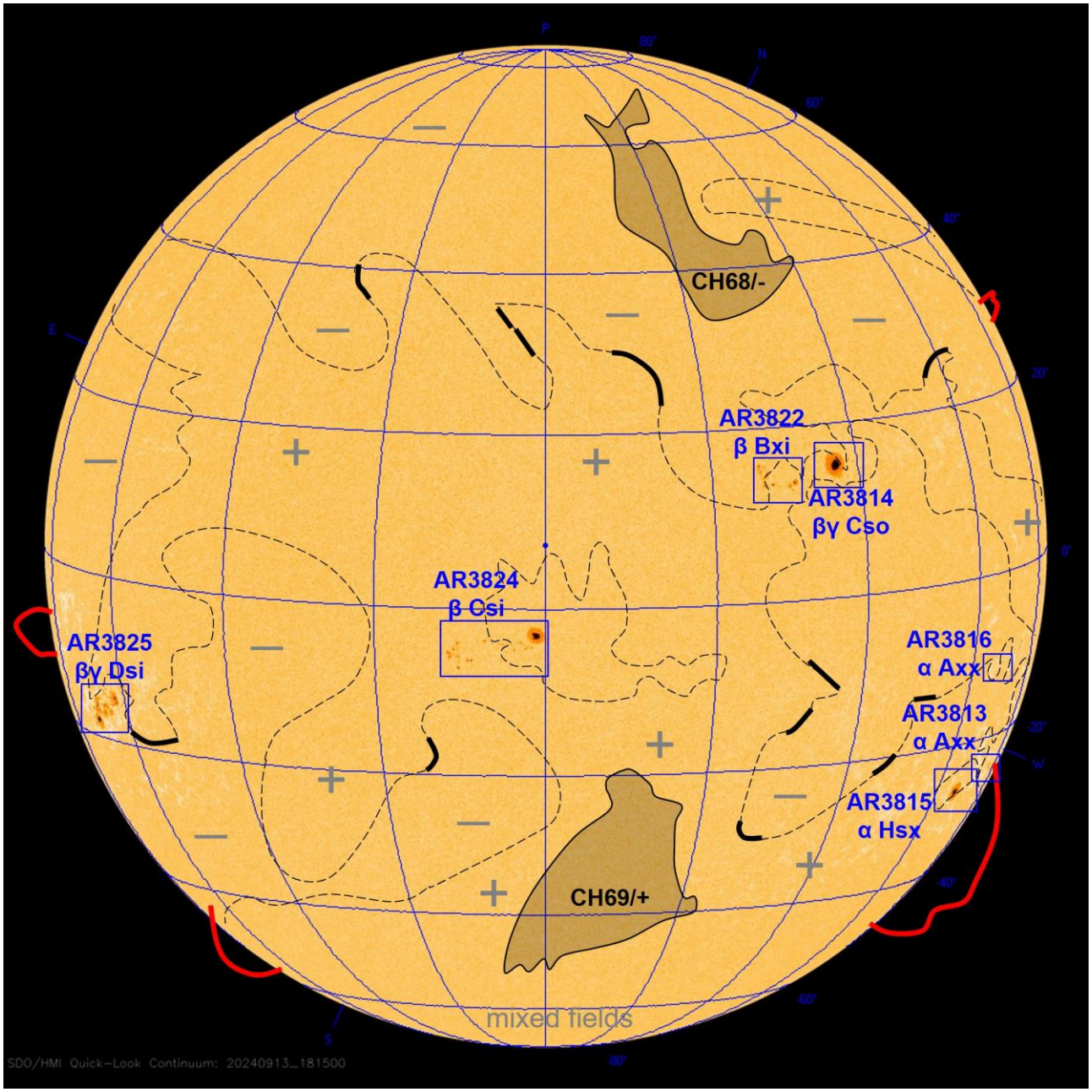
Figure 1. Solar Analysis Valid 13/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The CME that arrived on 12 Sep resulted in disturbed geomagnetic conditions. A further CME arrival is forecast to arrive early on Day 1 (14 Sep) but this is low confidence. This originated from the same sunspot as 12 Sep CME arrival, AR3814, from an M1.0 flares at 10/2350 UTC. This CME was slower and more diffuse however, suggesting a weaker arrival. A further potentially eruptive event occurred from AR3814 around 13/0900 UTC, although it is currently too early to assess the likelihood of any Earth-directed CME occurring.

Another CME was observed leaving the sun at around 13/0930 UTC, the result of a filament eruption, most likely associated with the M2.9 flare observed at 13/0835 UTC from AR3814. Its analysis revealed that the bulk of the ejecta is expected to pass ahead of Earth's orbit towards Stereo-A, however it may give a glancing blow on Day 3 (16 Sep).

Aside from these arrivals, there are also two coronal holes which may influence the forecast. CH68/- is the most westward of these, with any high speed stream likely connecting late on Day 2 (15 Sep), but is both quite far north and unfavoured for a significant connection at this time of year. CH69/+ is then most likely to connect on Day 3 (16 Sep) Confidence is low however, due to its southern location and Earth currently being above the solar equator. The bulk of any fast wind from this feature may subsequently pass south of Earth, as indicated on MOSWOC Enlil.

All things considered, geomagnetic activity is expected to be Active to G1/G2 Minor/Moderate Storms on Day 1 (14 Sep) with a slight chance of isolated G3 Strong storms possible. Mostly Quiet to Unsettled by Day 2 (15 Sep) but Unsettled to Active on Day 3 (16 Sep) with isolated G1 Minor Storm possible. Down to Quiet and Unsettled by Day 4 (17 Sep).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	70	5	30	5
Strong	G3	No	30	1	5	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
11/0657	Partial	M1.0 Flare AR3814	N30 01E	709 km/s	14/0500 UTC +/- 5hrs	Weak, diffuse CME
13/0930	Partial	M2.9 Flare AR3814	NW quadrant	667 km/s	16/0600 UTC +/- 6hrs	Glancing blow

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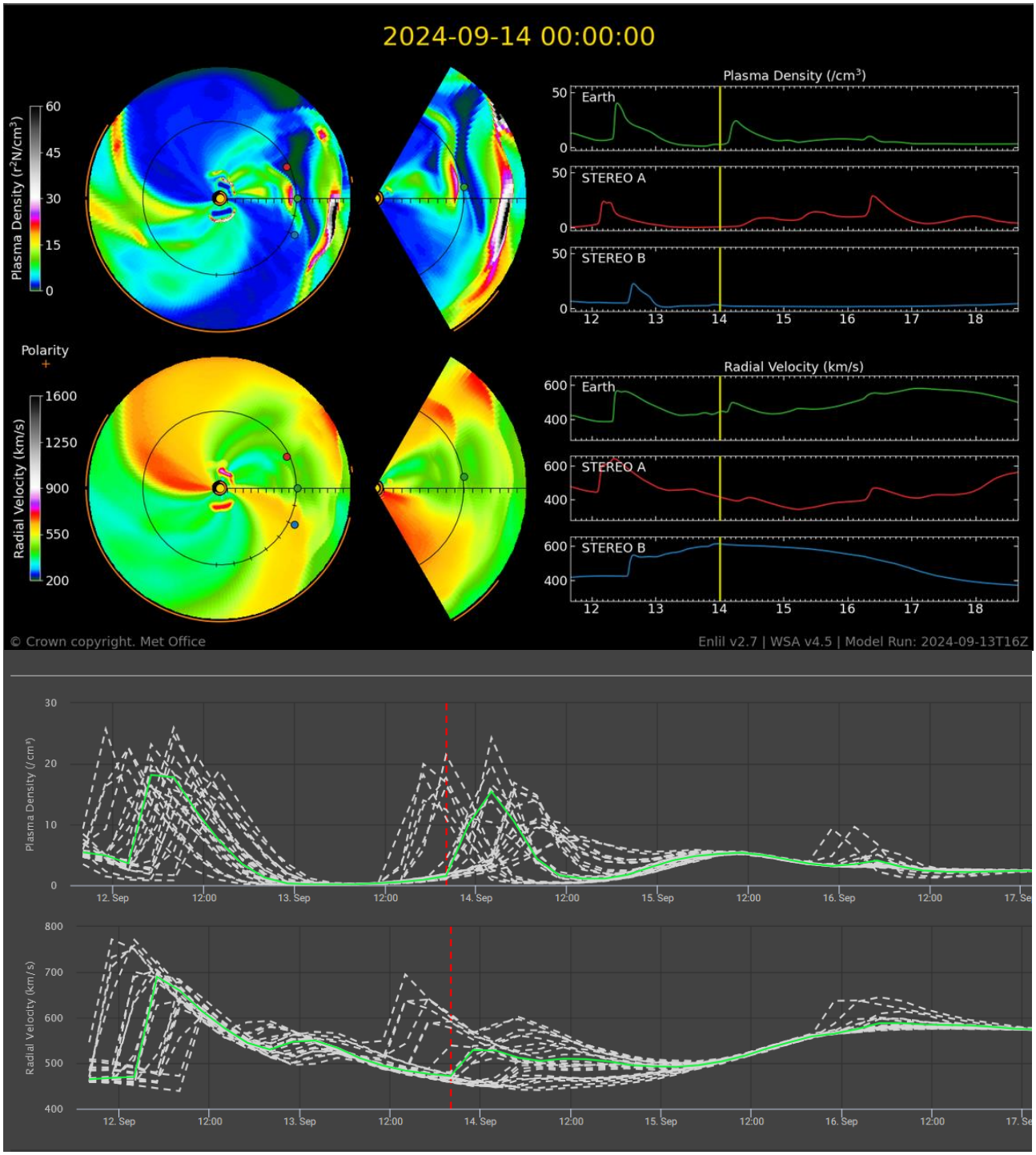
Figure 2: Enlil and Ensemble showing arrivals



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Radio Blackouts - X-Ray Flares:
Moderate to High activity expected, with further M-flares expected, and a chance of X-class flares.

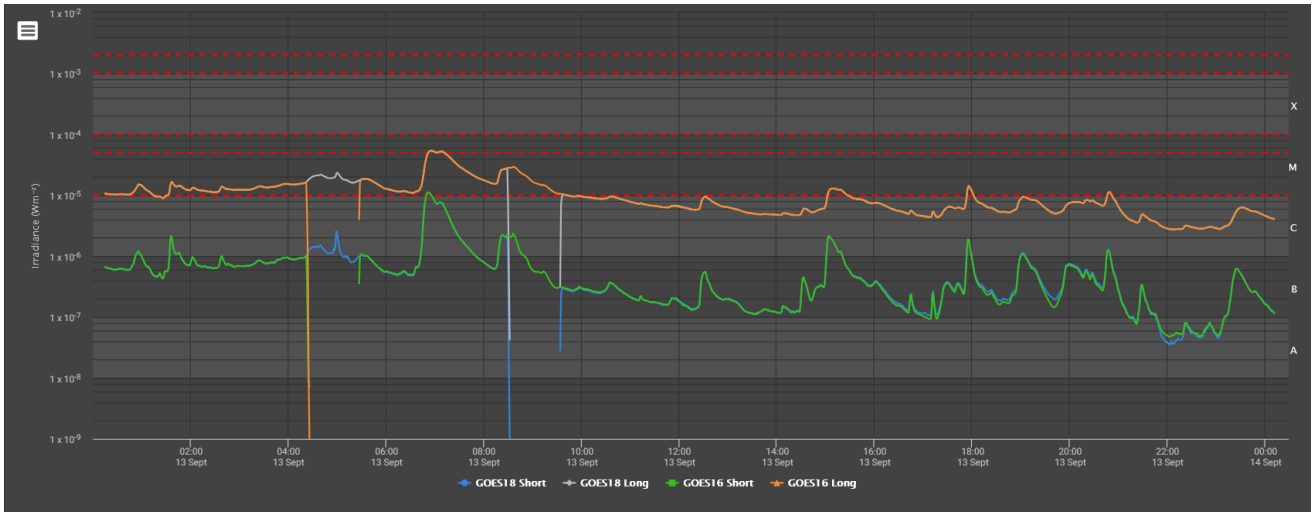
There are now seven visible regions on the disc, however the most active recent region is currently just over the southwest limb. This produced a large eruptive long period low M-flare, followed by a further M5 flare. Significant looping remains evident on SDO aia-94, and further flares remain likely from this region, although this risk is receding as it moves further onto the far-side.

The other region of note is AR3825 in the southeast. It is compact but magnetically complex and has been the source of the most recent M1 flares, as well as an X1.3 flare on 12 Sep. Once again, significant looping is evident on SDO aia-171, particularly between this region and the large plage currently emerging next to it on the southeast limb. AR3814 in the northwest has now faded.

With Ex-AR3811 now on the far side and moving further away from the west limb, the risk of further significant flares appears somewhat reduced compared to what it was 24 hours ago. The next notable region expected to emerge from the far side is not anticipated before Day 3 (16 Sept), leading to a slight increase in the probabilities.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 M Class**	Yes	60	60	70	70
Very Active	**R3 to R5 X Class**	No	10	10	10	10

Figure 3: Latest X-Ray flare activity, as observed at GOES-16 & GOES-18



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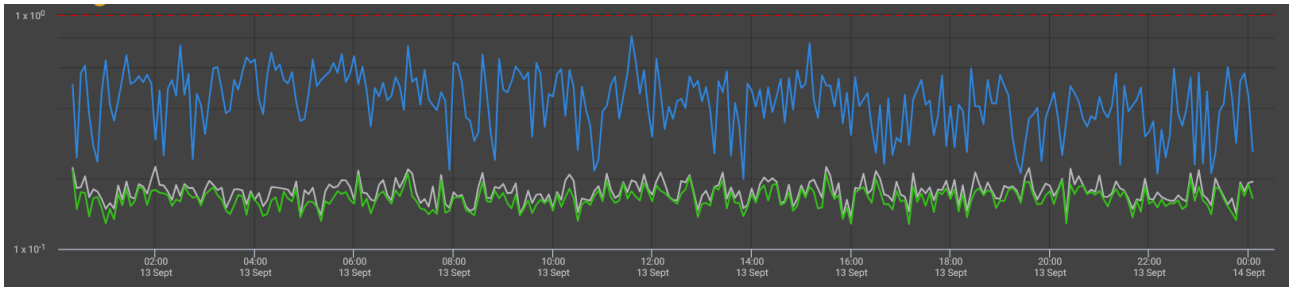
Solar Radiation Storms - (High Energy Protons):
High energy proton flux at GOES-18 is expected to persist at background, but with a slight chance of rising in response to any notable flares. The best candidate is currently Ex-AR3811 which has recently rotated over the southwest limb. This region has been responsible for multiple M-class flares over the last 24 hours, including an M5.4 observed at 13/0656 UTC. This region will gradually lose its flaring potential as it moves further away from the southwest limb, which could take a day or two.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	15	15	10	10
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Latest Proton Flux, as observed at GOES-18



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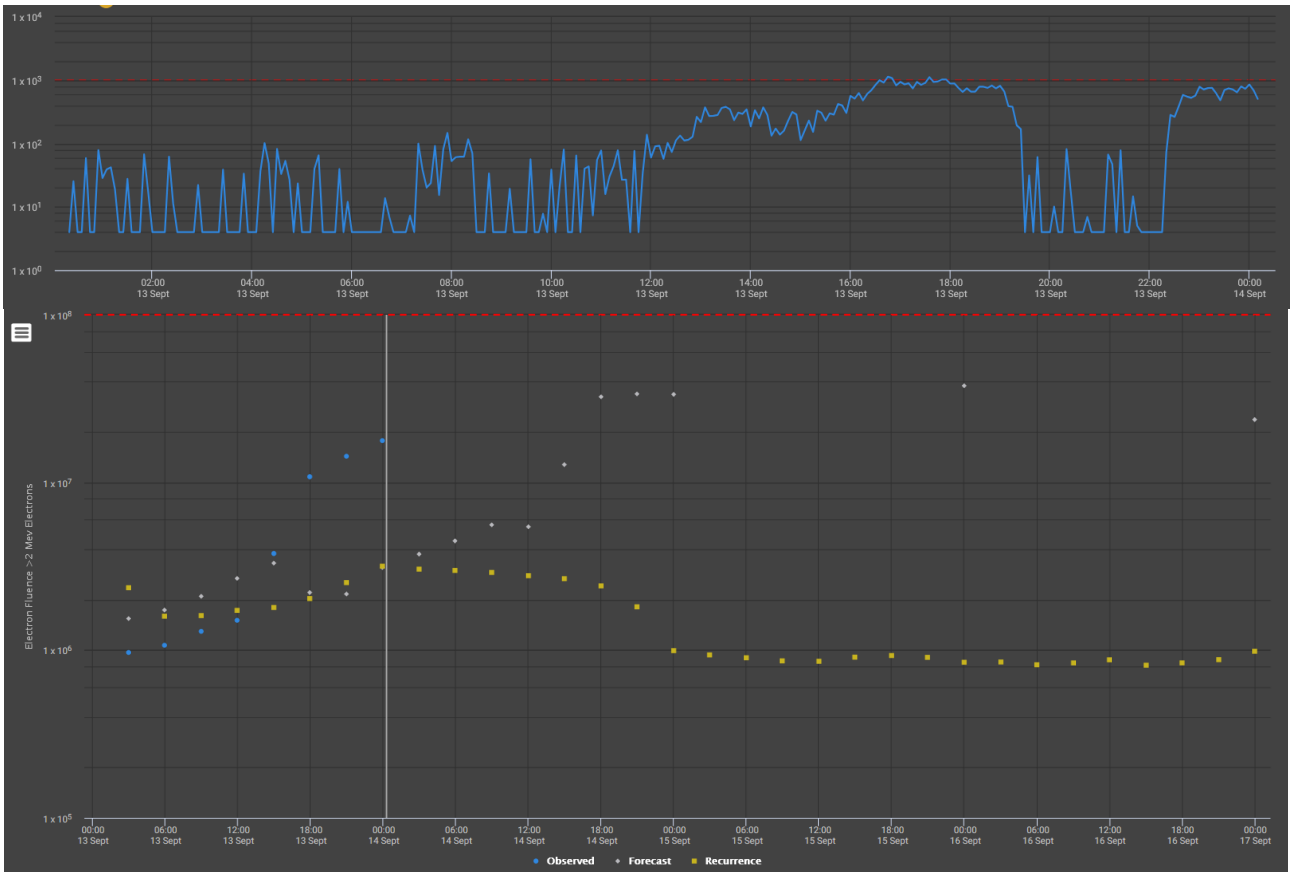
High Energy Electrons Event (≥ 2MeV):

The high energy electron flux briefly rose to elevated levels, demonstrating that some charging occurred after the geomagnetic storming that took place on 12 Sep. However, with two further CME arrivals anticipated - first one on Day 1 (14 Sep) and the second one on Day 3 (16 Sep) - plus the potential onset of the high speed stream of CH68 and CH69 on Days 2 & 3 (15 & 16 Sep), any rise is expected to be brief and the high energy flux most likely to stay close to Background levels.

The associated 24-hour fluence is expected to remain below the Active level. The latest MOSWOC REFM output is currently showing a rise, however this is misleading as it isn't taking into account any CME impacts or possible coronal hole interactions.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: Current Electron Flux, as observed at GOES-16. Latest REFM output.



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